Surface Atmosphere Radiation Budget (SARB) working group update

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Help from Cloud and TISA groups

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Hampton, Virginia

Outline of this presentation

- Overview of importance of surface irradiance
- Ed4 SYN (4 month test cases)
- MERRA2 evaluation and the difference with and without AIRS (Rose)
- GEOS and surface irradiance evaluation with MAGIC (Rutan)
- Multi-layer cloud algorithm evaluation (Viudez-Mora)
- Radiance (spectral) comparison over Dome-C (Radkevich)
- Surface emissivity (Ham)
- NPP CRS (201202)
- Future direction

Ed4 – Ed3 (global monthly mean)

		Oct. 2001	Oct. 2002	July 2004	Jan. 2010	April 2013
TOA	SW UT	2.44	0.48	2.07	3.71	1.88
	LW UT	-0.39	1.33	0.47	0.96	1.56
Surface	SW down UT	-3.03	-1.25	-2.42	-5.21	-3.62
	SW down UT (clear)	0.87	0.55	1.11	0.26	0.56
	LW down UT	5.31	5.22	6.57	3.98	4.69
	LW down UT (clear)	2.31	3.58	3.43	0.56	0.68
Cloud cover	Low-level (%)	3.93	2.69	4.58	3.55	3.37
	Total (%)	4.95	6.04	8.29	5.76	5.42

Ed4 SW down is smaller and LW down is larger compared with Ed3.
This is largely due to a larger low-level cloud cover in Ed4 for the GEOS-5.2 period.
For GEOS-4 period, a larger near surface temperature accounts for about a half of LW increases.
GEOS was switched from 4 to 5.2 starting Jan. 2008 in Ed3

TOA computed (UT) – Obs.

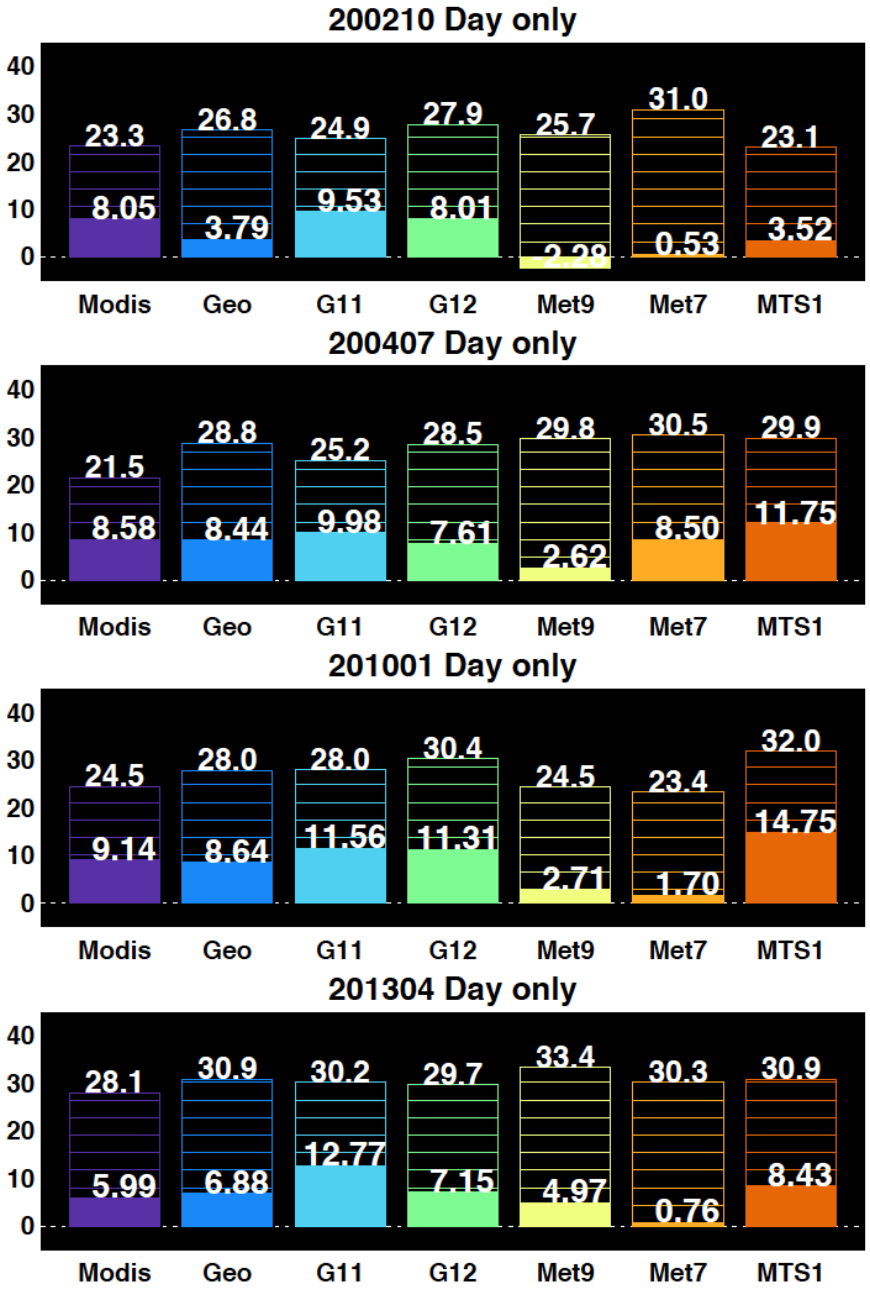
		Oct. 2002	July 2004	Jan. 2010	April 2013
SW	Ed4	1.76	3.53	3.83	2.76
	Ed3	1.39	1.35	1.06	0.96
LW	Ed4	0.05	-0.57	-0.70	-0.59
	Ed3	-1.36	-1.20	-1.93	-2.16

Reflected SW difference from observations increases going from Ed3 to Ed4 because a larger cloud fraction

	Satellite	Oct. 2002	July 2004	Jan. 2010	April 2013	GEO type
-75 deg	GOES-8	X				4
	GOES-12		X	X		5
	GOES-13				X	5
-135 deg	GOES-10	X	X			4
	GOES-11			X		4
	GOES-15				X	5
0 deg	Met-7 0°E	X				3
	Met-8		X			6
	Met-9			X		6
	Met-10				X	6
63 deg	Met-5	X	X			3
	Met-7 60°E			X	X	3
140 deg	GMS-5	X				3
	GOES-9		X			4
	MTSAT-1			X		4
	MTSAT-2				X	4
	Terra MODIS	Ed4-ASDC	Ed4-ASDC	?	?	1
	Aqua MODIS	Ed4-ASDC	Ed4-ASDC	Ed4-offline	?	2
	GERB		X	X		

3: 3 channels
4: 5 channels with 12 micron channel GEO
5: 5 channels with 12 micron channel is replaced by 13.2 channel
6: 5 channels with both 12 and 13 channels

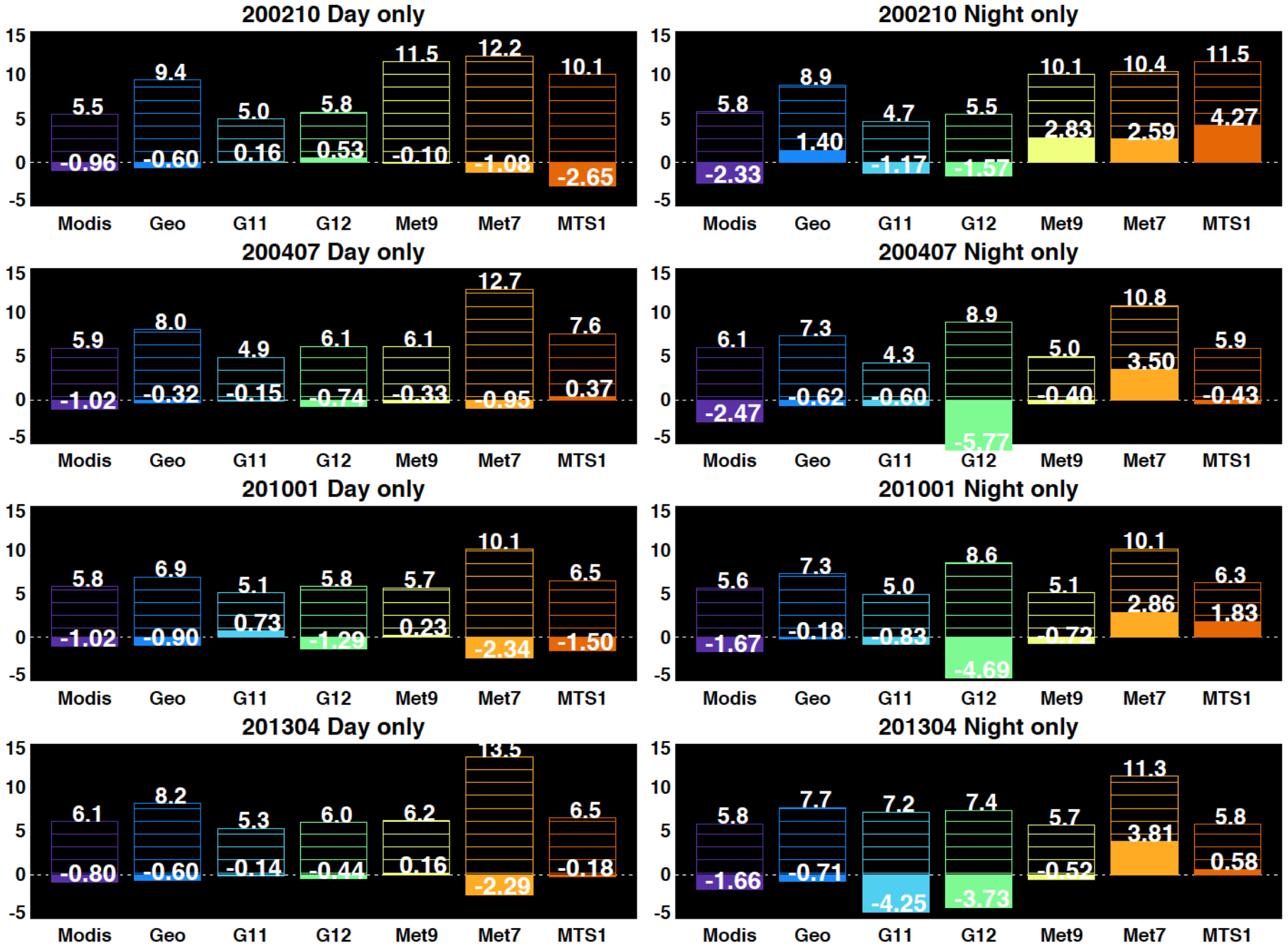
Ed4 SYNI Computed SW TOA bias & RMS error by satellite



A larger Ed4 cloud cover than Ed2 cloud cover is largely responsible for the difference

Ed4 SYNI Computed OLR Bias & RMS error
10deg Zonal Subset 60N/S

Apr22



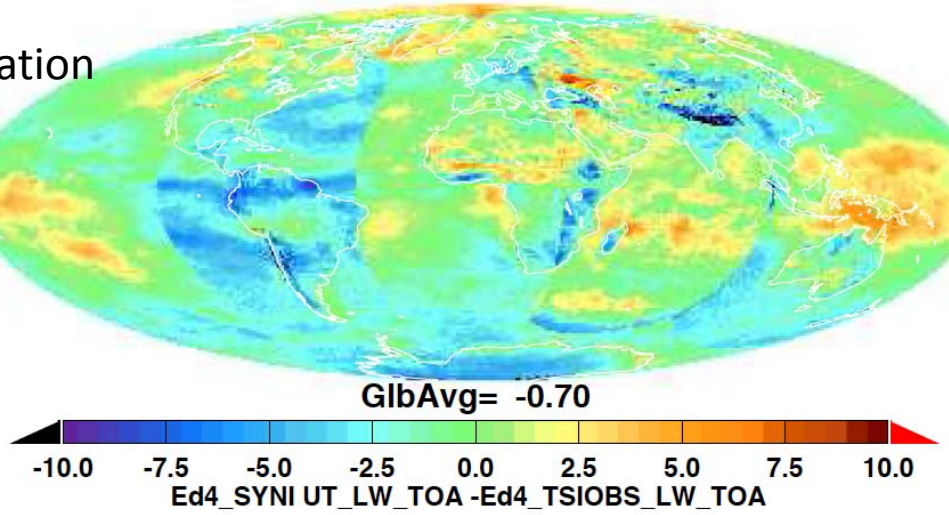
Ed4 Validation plots (monthly)

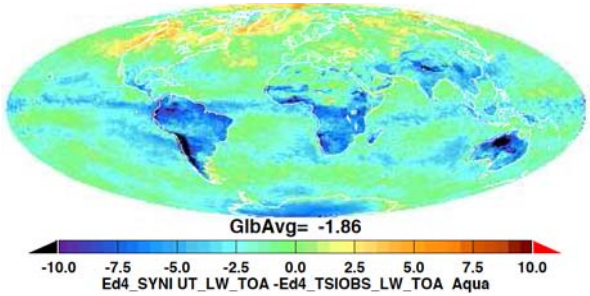
Syni.ed4-ed3.*.v3.Apr22.pdf	comparison with Ed3	
CER_TSI_SYNI_ABS.ed4.*.v3.*.pdf	TOA flux comparison separated by Terra, Aqua, and GEO	
Syni_Tsi.*.stats_by_sat.*.pdf Barplt.4seasonal.pdf	OLR comparison by MODIS and GEO	
Zonal_geo_modis_cloud.*.pdf	GEO cloud fraction vs. MODIS cloud fraction	Need special TSI and not for all months
Bylayer.v4.pdf	Cloud overlap	Not for all months
SW-sfc-dn.*.pdf, LW-sfc-dn.*.pdf	Surface validation of hourly irradiancs	
lw.dc.LND.pdf, sw.dc.LND.pdf, lw.dc.OCN.pdf, sw.dc.OCN.pdf	Monthly mean diurnal cycle comparison	

These plots will be made separate from internal subsetter

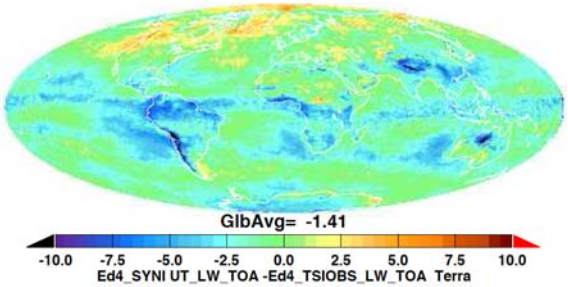
TOA irradiance comparison (Jan. 2010)

Monthly mean
Ed4 untune - Observation

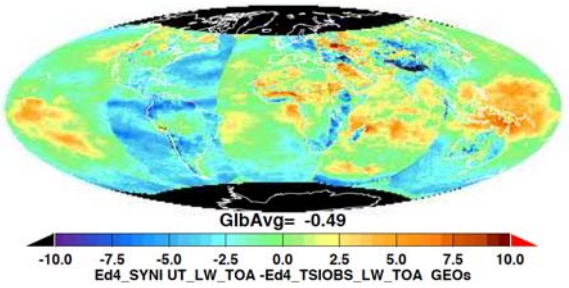




Aqua overpass time



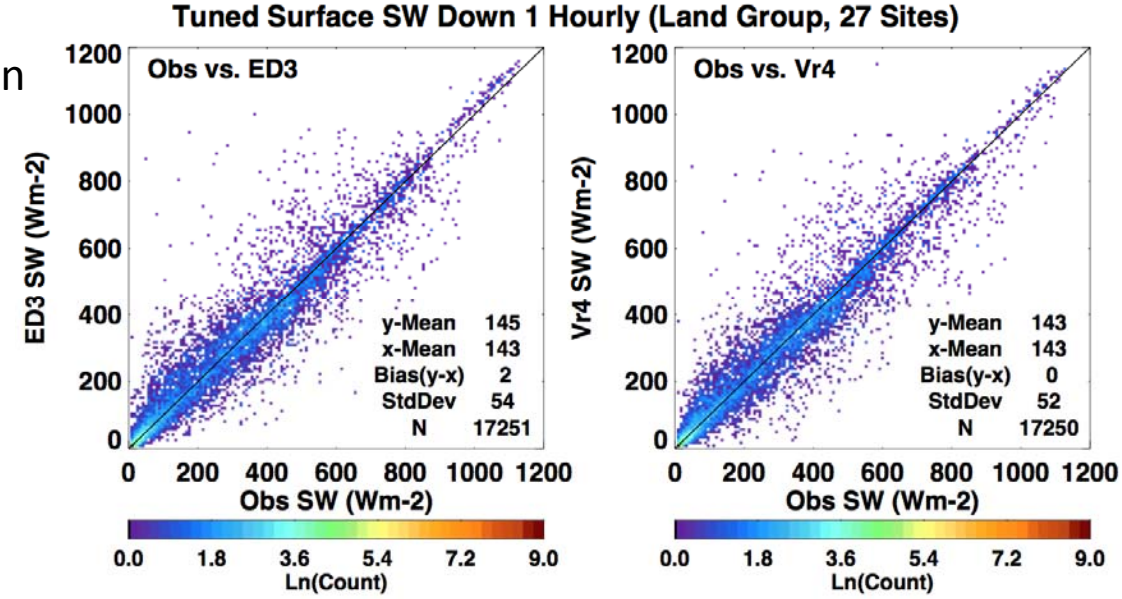
Terra overpass time



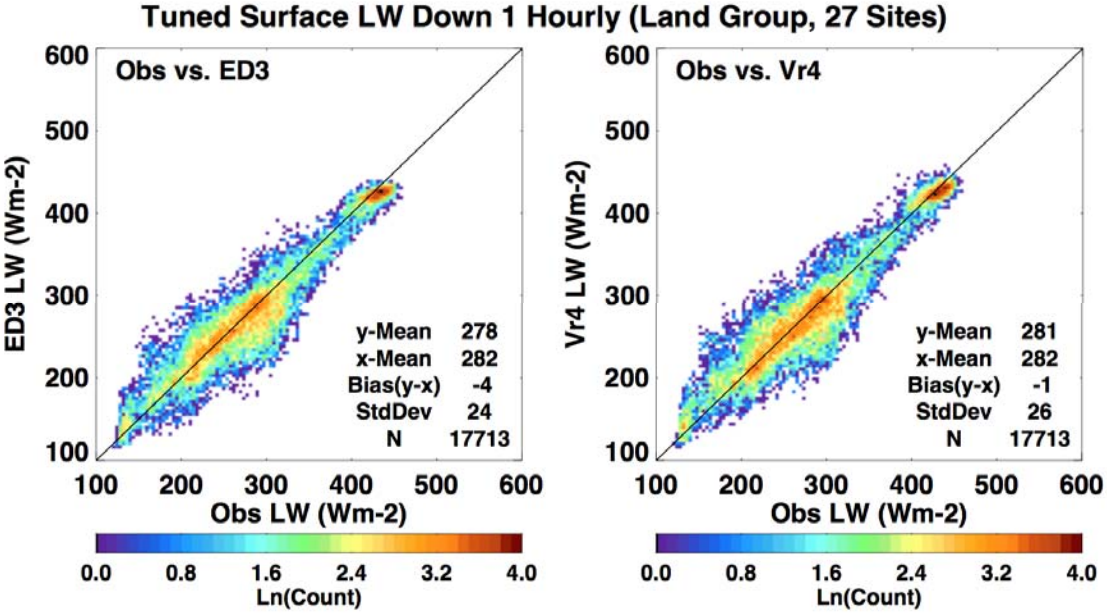
Geo time

Surface validation (Jan. 2010)

Shortwave down



Longwave down



Hourly surface irradiance comparison over land bias (standard deviation) in Wm^{-2}

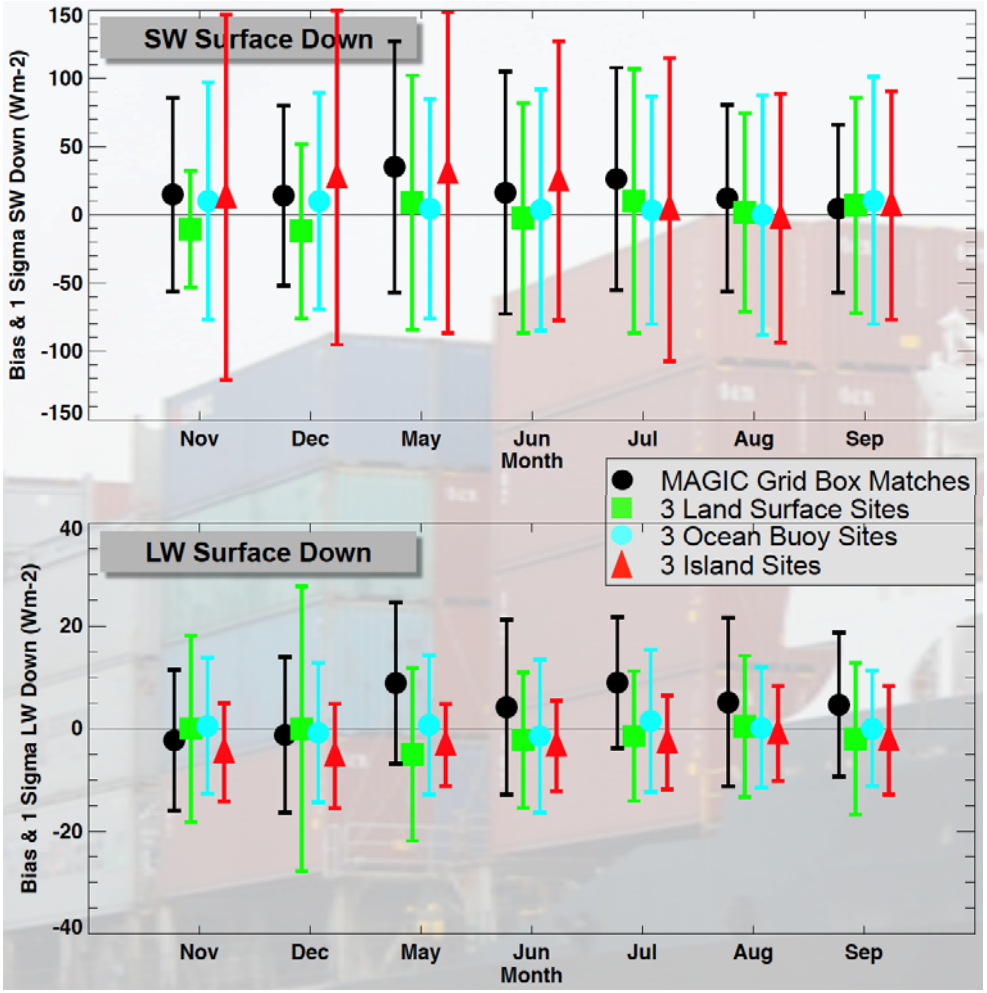
		Oct. 2002	July 2004	Jan. 2010	April 2013
TOA	SW up UT Ed4	-1 (21)	-2 (24)	-2 (22)	-3 (24)
	SW up UT Ed3	1 (16)	-2 (18)	0 (17)	-1 (21)
	LW up UT Ed4	-2 (13)	-1 (13)	-1 (13)	-2 (13)
	LW up UT Ed3	-2 (11)	-2 (12)	-3 (11)	-2 (12)
SFC	SW dn TU Ed4	5 (59)	0 (67)	0 (52)	-3 (62)
	SW dn TU Ed3	6 (57)	2 (68)	2 (54)	-3 (67)
	LW dn TU Ed4	2 (23)	5 (21)	-1 (26)	4 (25)
	LW dn TU Ed3	-5 (23)	-5 (21)	-4 (24)	1 (24)

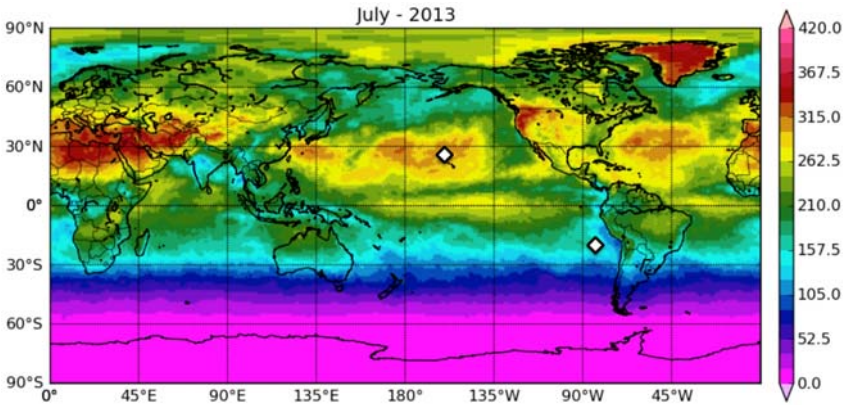
Ed3 and Ed4 bias is nearly equal.
Ed4 LW down is improved compared with Ed3 (G541 vs. G4 or G52)
Ed4 anomaly time series is expected to improve

MERRA2

- Telecon presentation (base)
- UTRH (land ocean separately -> global map)
- MERRA spectral emissivity and how does MERRA clear-sky OLR agree with CERES?
- Sensitivity of OLR to UTRH and skin temperature (forward computation of spectra?)
- Surface flux difference with MERRA with and without AIRS (ordering tool)

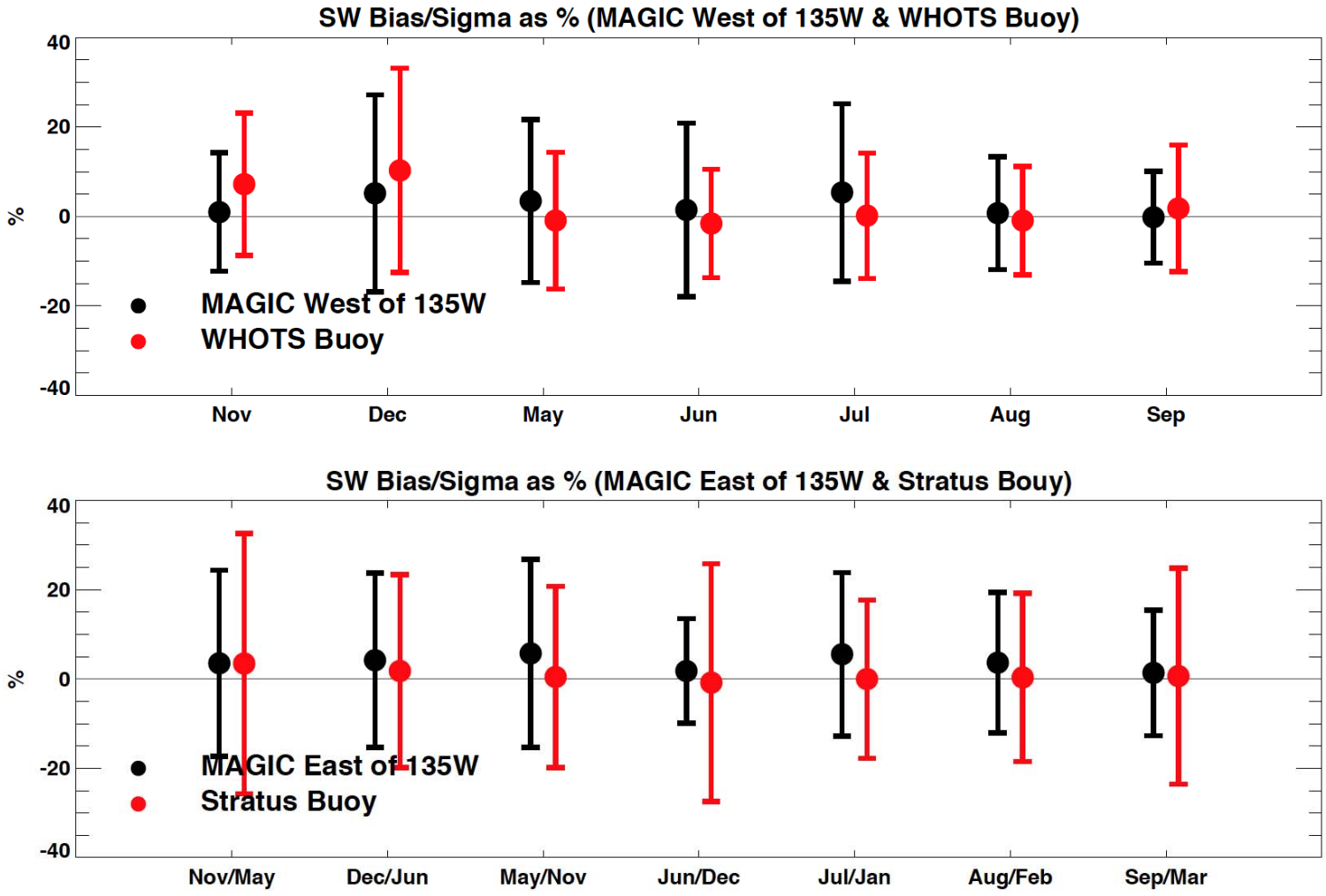
Comparison with MAGIC data





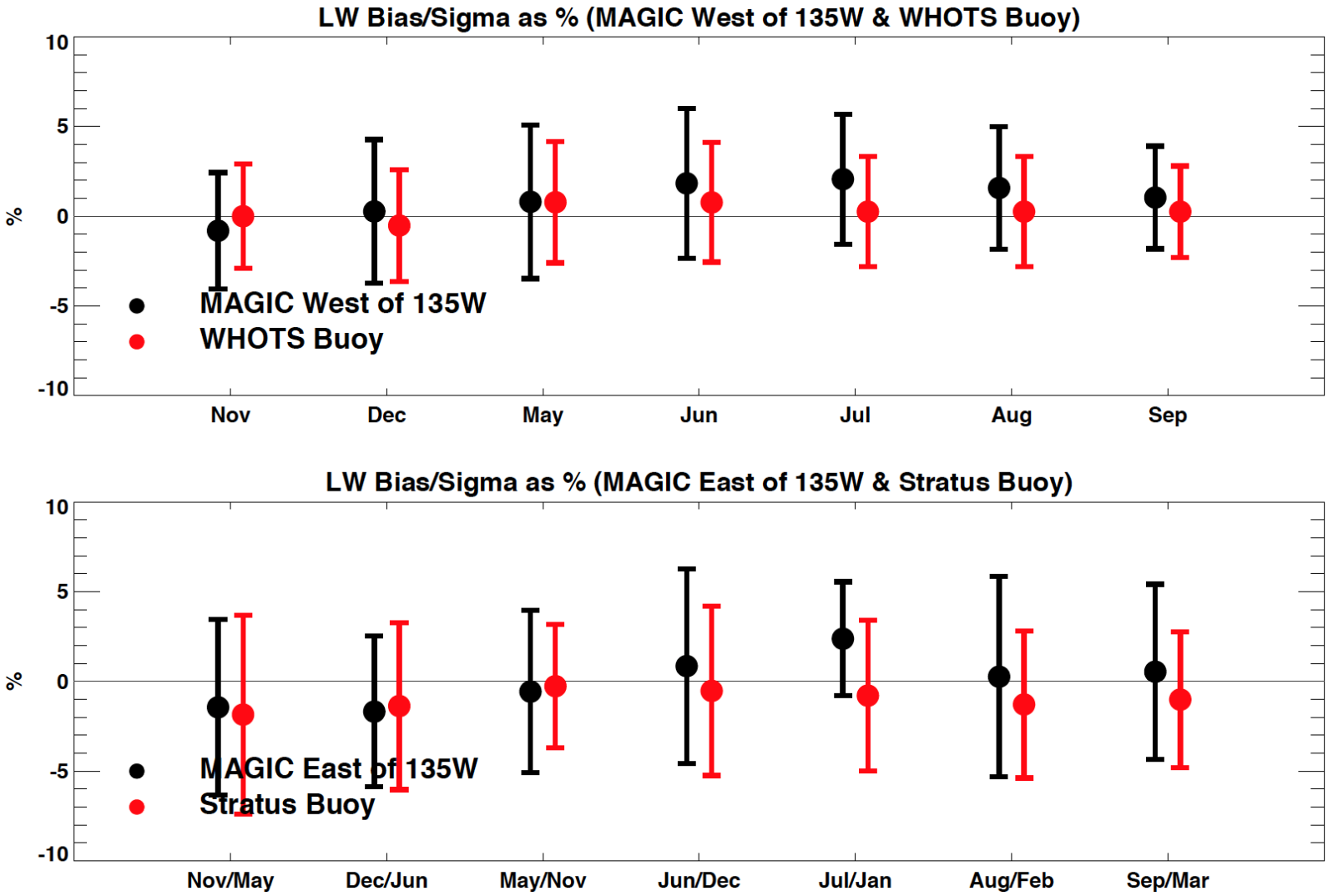
The difference between computed and observed irradiance is larger with MAGIC data than the difference computed with buoy data

Downward shortwave comparison



We do not know the reason for the larger difference with MAGIC data yet

Downward longwave comparison



Similar to shortwave, We do not know the reason for the larger difference with MAGIC data yet

Multi-layer clouds

- How often does the multi-layer cloud algorithm give us correct information (compared with CALIPSO/CloudSat).
- When and what information can we trust?

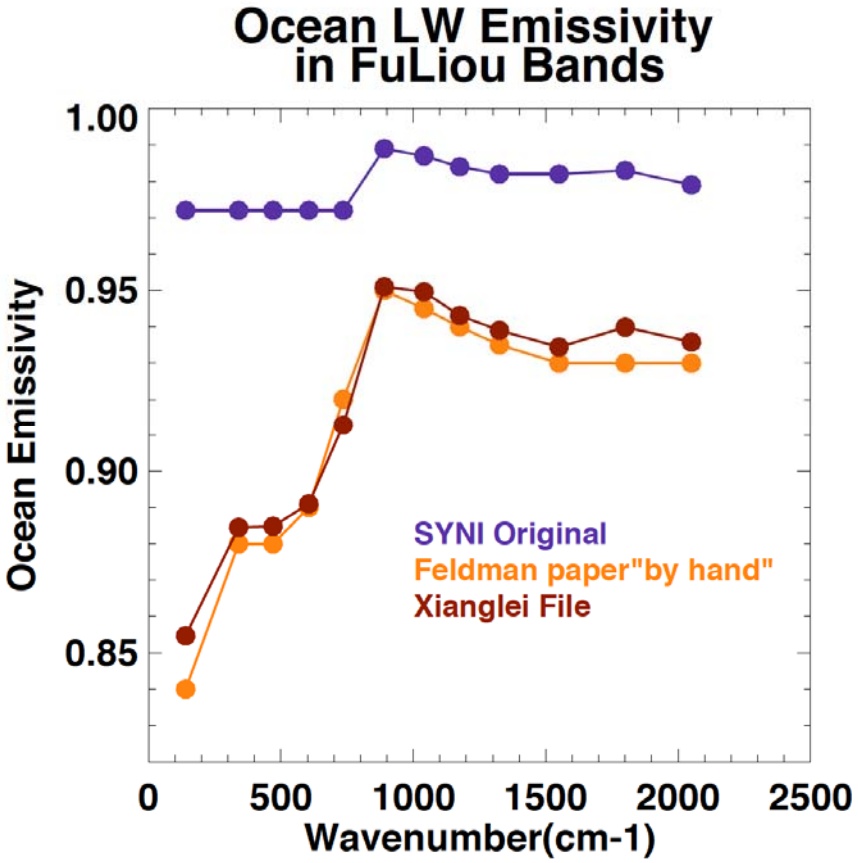
Radiance comparison over Antarctica

- Any new radiance comparison (Terra, Aqua, and NPP)?
- Spectral comparison (MODIS, SCHIAMACHY)?

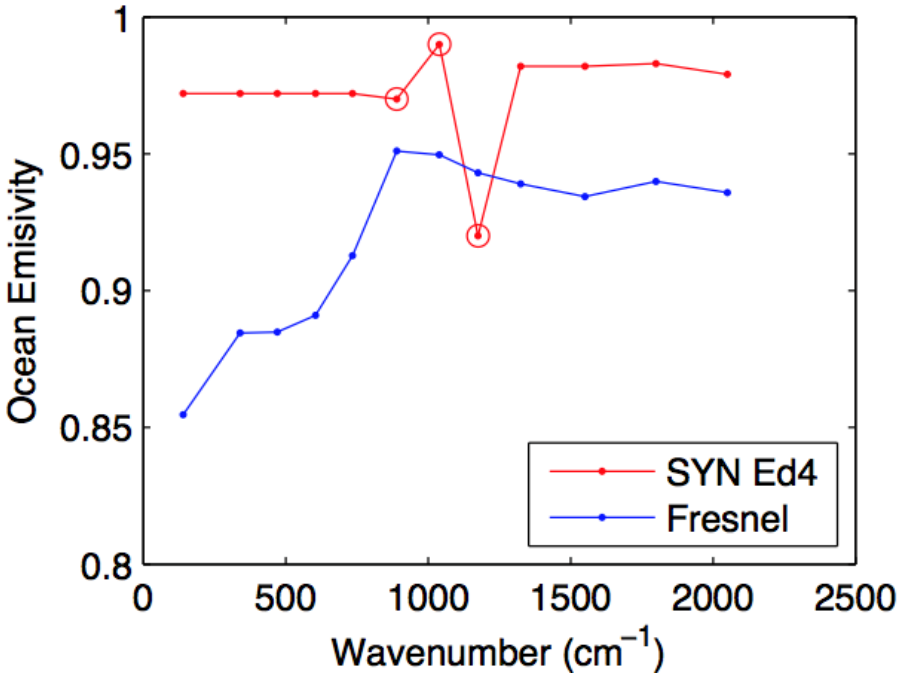
Surface emissivity

- Comparison of Ed4 emissivity and Feldman et al. for ocean.
- Correction for the 2-stream model (parameterization using two angles (anisotropic factor at mu = 0.21 and 0.79 with a function of column water vapor?)
- Cloud group's window emissivity for water (0.92? 0.99, 0.97)
- Comparison of Ed4 emissivity and Dan Zhou's retrieved values for land by IGBP

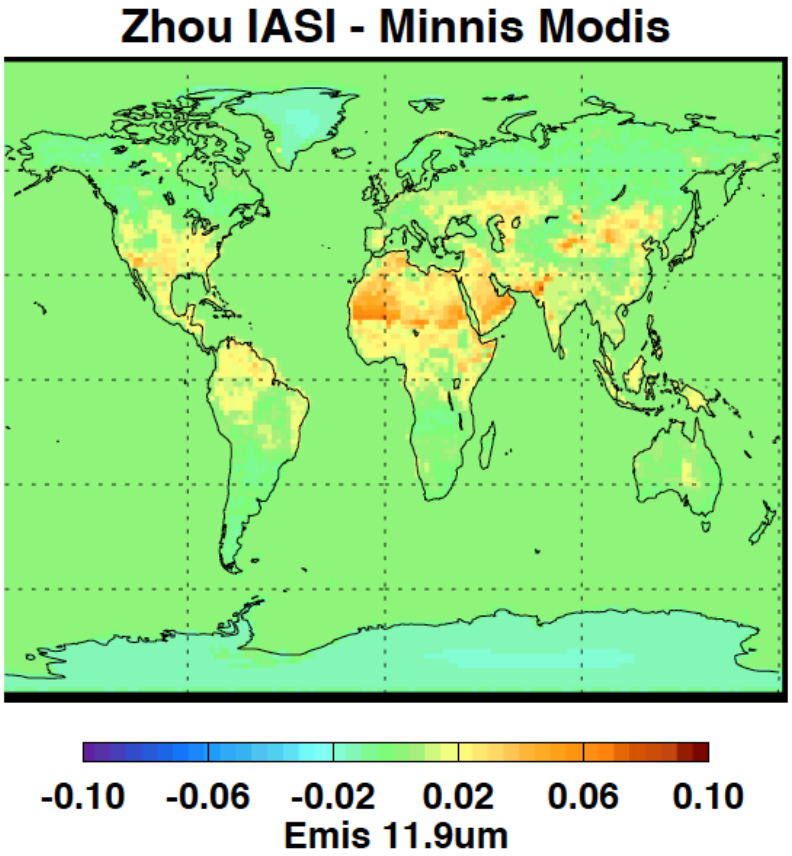
Ocean emissivity



Emissivity in 3 window bands are replaced by those provided by the cloud group

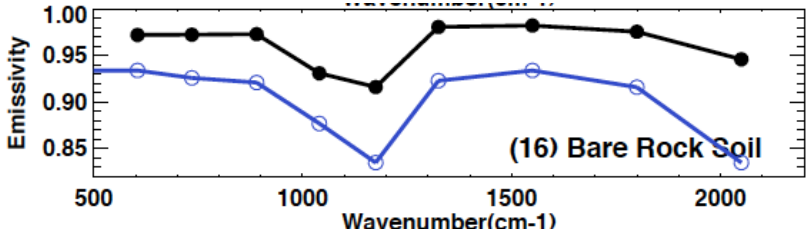


Land (desert) emissivity comparison



Black: Zhou et al. 2013 from IASI

Blue: Ed4 SYNI

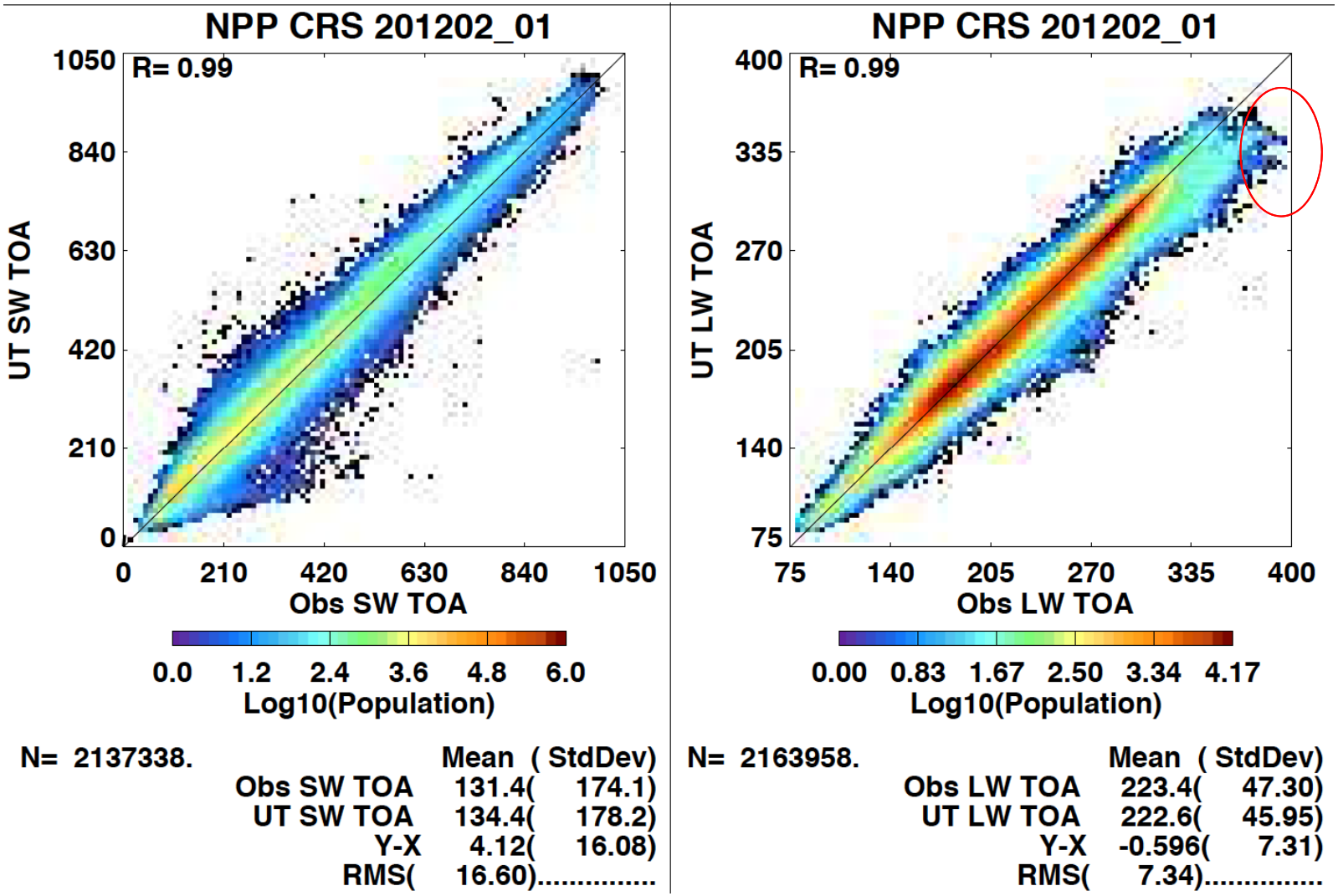


0.05 emissivity difference between 10.2µm to 12.5 µm is equivalent to ~1.6 K skin temperature difference

NPP CRS

- Comparison of 201202 CRS1deg-month with SYN and EBAF.
- Instantaneous TOA flux comparison with CERES

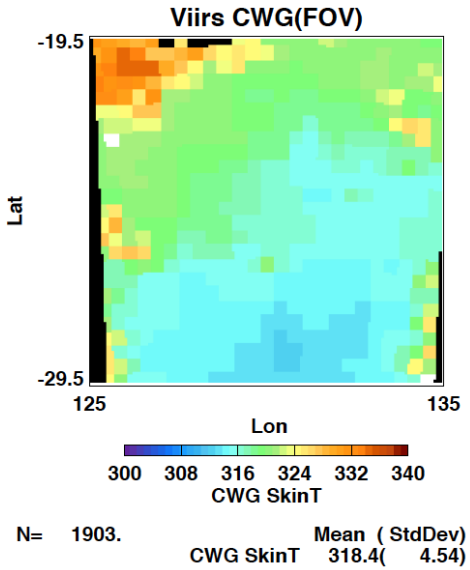
Instantaneous flux comparison at TOA

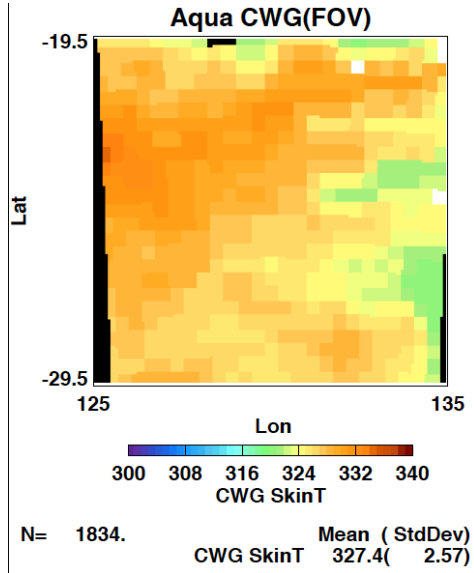


Skin temp derived from VIIRS

Skin temperature Feb. 1st 2012 5Z

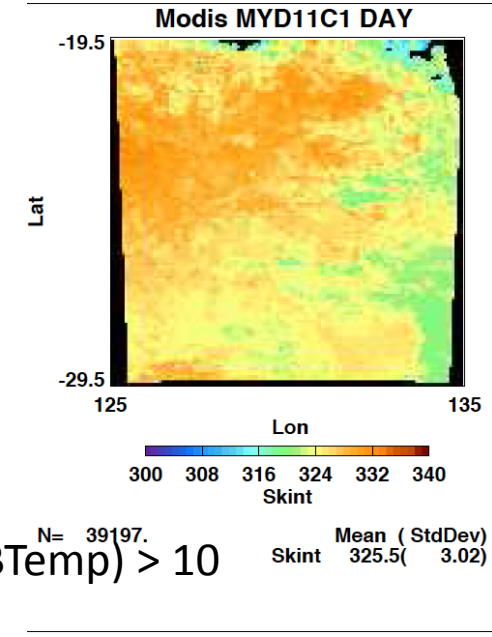
VIIRS

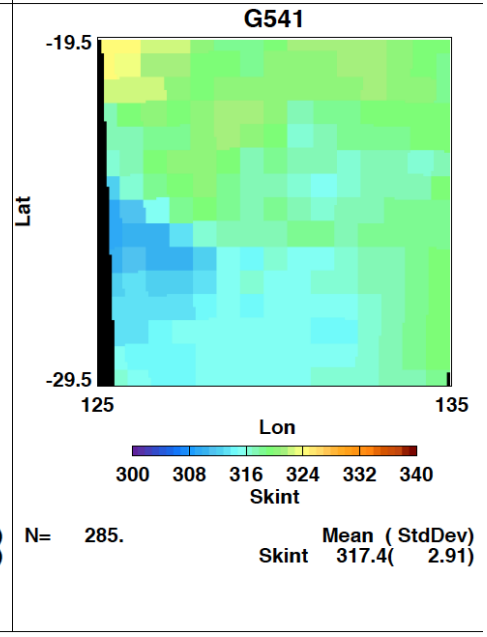




Aqua Ed2

MODIS product

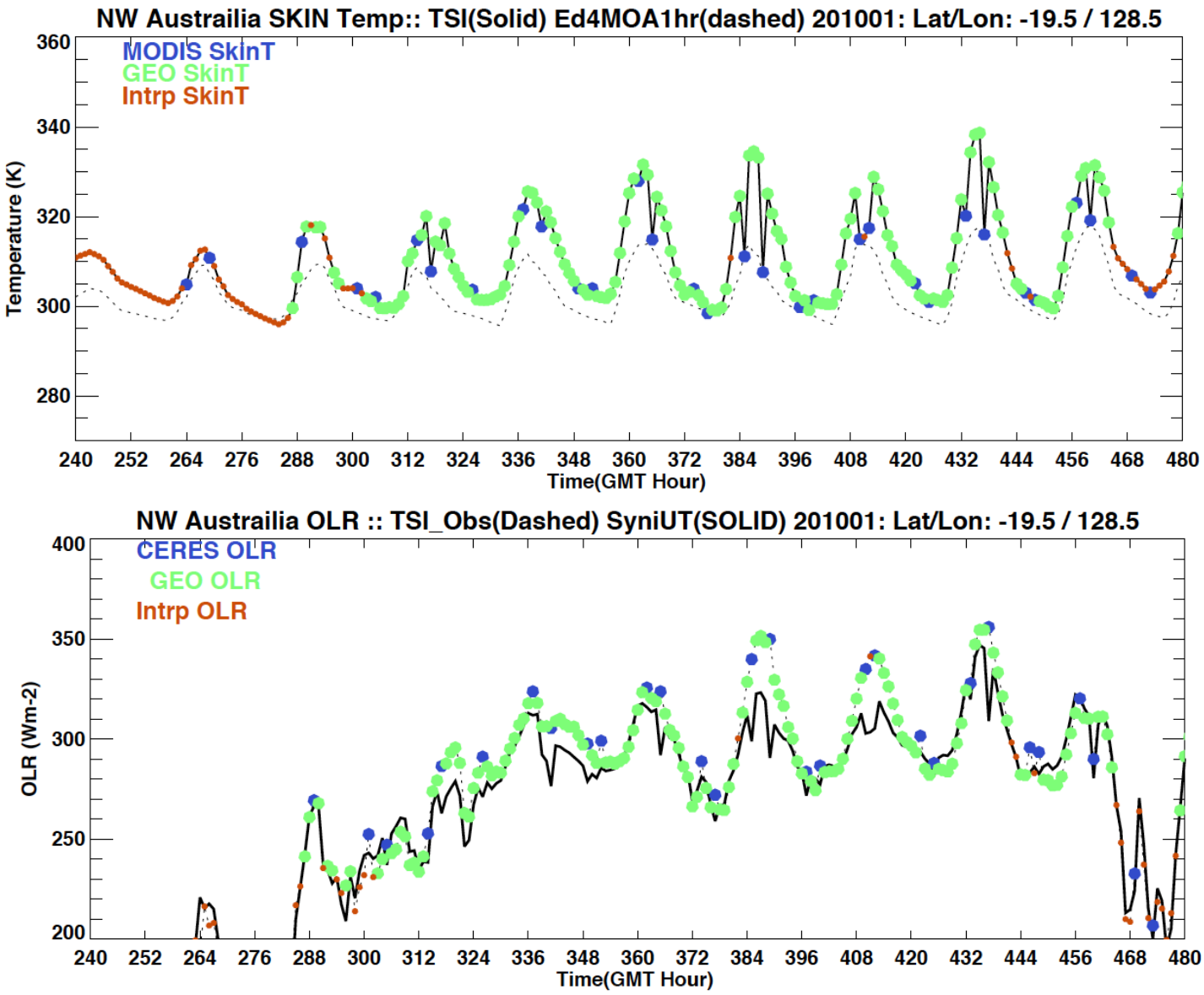




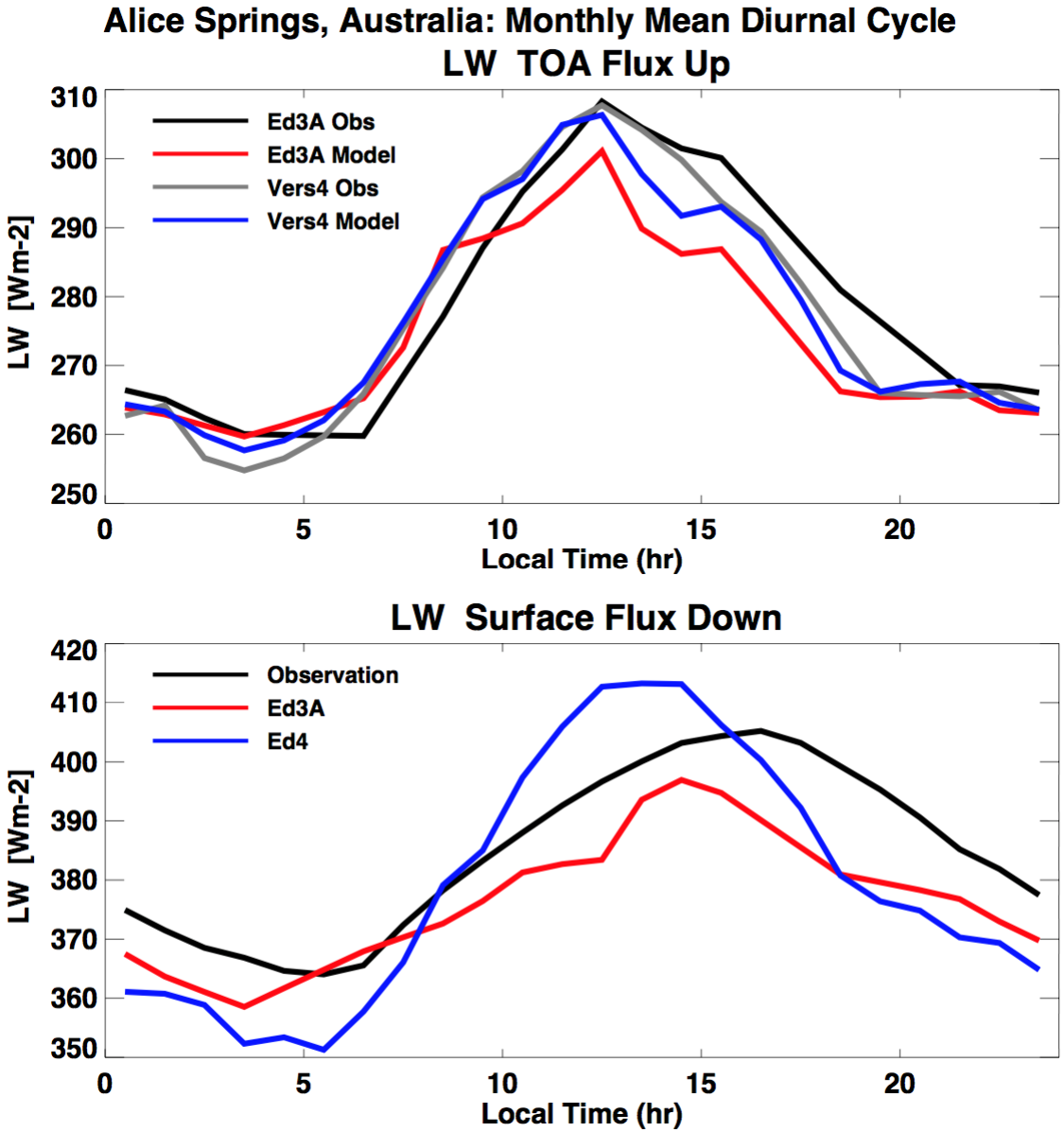
G541

This happens in Ed4 when abs(moaSkinT-to-TOA – obsBTemp) > 10

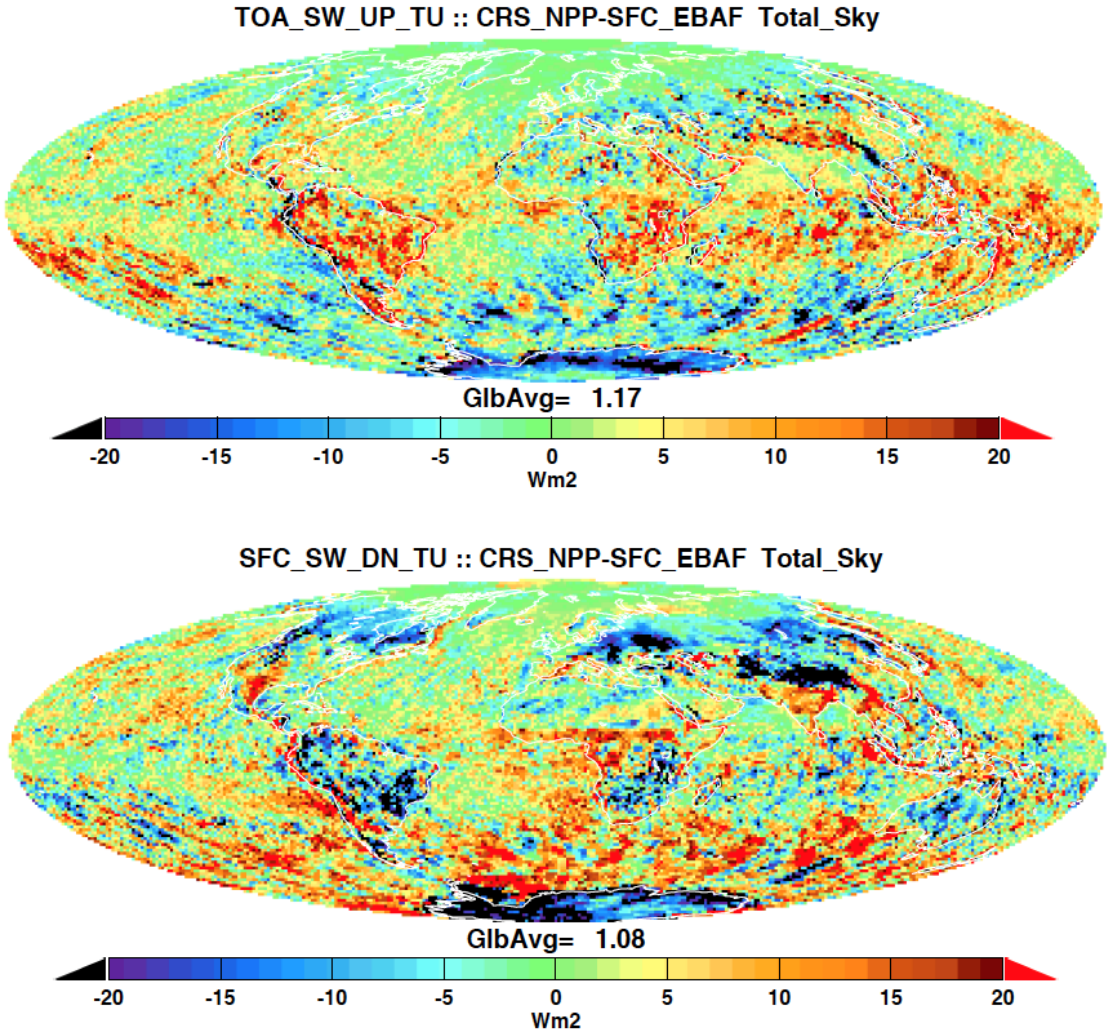
Skin temperature over the NW of Australia



Alice Springs, Australia (-23.70, 133.87) for Jan. 2010



Monthly mean SW comparison with EBAF



Apparently the SW down at the surface difference slightly depends on surface type (land and ocean), but there is no extremely large differences.

Future direction

- **Algorithm development and maintenance**
  - Extending EBAF Ed2.8 and develop an improved algorithm for EBAF Ed4.
  - Production code modernization effort .
- **Input data stream**
  - Improve (T and Q) GEOS-541 for Ed5 by corroborating with GMAO (using MERRA2 as a base). Our role is to evaluate GEOS-541 and MERRA2 and to give GMAO feedback.
  - Comparison with surface observations (especially over ocean)
    - Use of ship data and field campaign data
    - Make validation results more visible to CERES data users on the CERES WEB site
  - Study of the effect of MODIS versus VIIRS (clouds and aerosols) to surface radiation budget.
  - Assess the impact of no cloud observations from an AM orbit (i.e. no Terra).
  - Smooth transition of surface radiation budget when geostationary satellites are changed.
- **Provide uncertainty estimates of surface and within-atmosphere fluxes through validation activities**
  - Improve polar radiation budget
    - Use ARISE data
    - Look for more surface validation sites
  - Consistency check by integrating precipitation, atmospheric advection, and surface latent and sensible heat fluxes (as a part of data product validations).
- **Documentation**
  - Peer-review paper of Ed4 SYN algorithm and evaluation
  - SYN and CRS collection guides

Publications

Published

- Ham, S.-H., S. Kato, H. W. Barker, F. G. Rose, and S. Sun-Mack, 2015: Improving the modeling of short-wave radiation through the use of a 3D scene construction algorithm, Q. J. R. Meteorol. Soc., DOI:10.1002/qj2491.

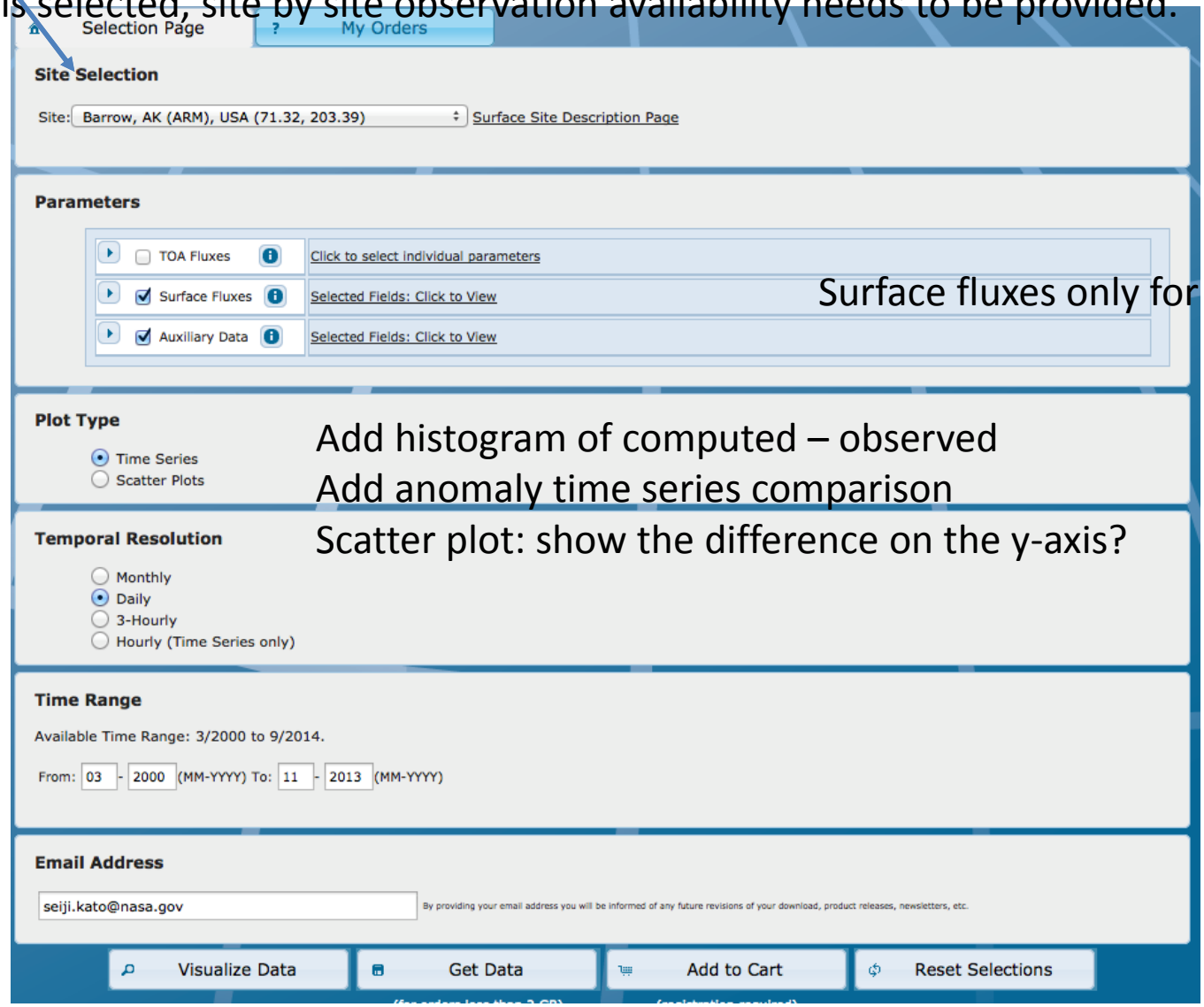
In Press

- Rutan, D. A., S. Kato, D. R. Doelling, F. G. Rose, L. T. Nguyen, T. E. Caldwell, and N. G. Loeb, 2015: CERES synoptic product: Methodology and validation of surface radiant flux, *J. Atmos. Ocean. Tech*., *In press*.

Submitted

- Kato, S., N. G. Loeb, D. A. Rutan, and F. G. Rose, 2015: Clouds and the Earth's Radiant Energy System (CERES) data products for climate reserch, submitted to J. Meteorol. Soc. Japan.
- Kato, S. and N. G. Loeb, 2015: Period dependent short-term shortwave and longwave feedback parameters derived from CERES observation, submitted to J. Climate.

When a region is selected, it brings up a list of surface sites in the region
User can select from plotting all sites together or separately, if plotting together is selected, site by site observation availability needs to be provided.



Surface fluxes only for EBAF-surface

Add histogram of computed – observed
Add anomaly time series comparison
Scatter plot: show the difference on the y-axis?

SYN1deg

- Show SYN1deg values for diurnal average (time series, hourly)
- Show SYN1deg values for 10 m temp, surface relative humidity, precipitable water

Back-ups

Ed4 SYN

- April 22 run is produced with codes delivered to DAAC.
- A set of plots that can be used for QC check
  - Syni.ed4-ed3.*.v3.Apr22.pdf (comparison with Ed3)
  - CER_TSI_SYNI_ABS.ed4.*.v3.*.pdf (TOA flux comparison separated by Terra, Aqua, and GEO).
  - Syni_Tsi.*.stats_by_sat.*.pdf and Barplt.4seasonal.pdf (OLR comparison by MODIS and GEO)
  - Zonal_geo_modis_cloud.*.pdf (GEO cloud fraction vs. MODIS cloud fraction, not for all months since it needs a special TSI)
  - Bylayer.v4.pdf (cloud overlap)
  - Ed3ed4-*.pdf, lw.dc.LND.pdf, sw.dc.LND.pdf, lw.dc.OCN.pdf, sw.dc.OCN.pdf (surface validation)